recovery of layered (a.k.a. Muong-Nong) Australasian tektites *in situ* throughout a region extending from the Laotian border westward to a line connecting Ban Pho Klang near the Mekong River in the northeast through Det Udom to Nam Yun in the south. With two exceptions in sites near the western edge of this region, all recovered fragments are layered. In most cases large layered tektites are found by rice farmers in fields that were forested until the recent past. We were shown exact locations where kilogram-sized tektites had recently been recovered, and we purchased several large specimens. Wherever laterite shot was exposed on the surface, we found many small layered tektites in place.

The layering of layered tektites appears to have formed by downslope flow. The structures closely resemble layering found in obsidian flows, and the 20° dip of the magnetic remanence relative to the layering shows that the glass masses were *in situ* on the Earth's surface when they cooled through the Curie temperature. Our observations indicate that a geographical area with minimum dimensions of 40 × 130 km was covered with a sheet of silicate melt. This seems to require that the region was continuously heated by radiation associated with the accretion of extraterrestrial material until the melt had rained out onto the surface; to achieve the observed amount of flow a mean radiation temperature of ~2200 K was required. The highly luminous sky was partly produced by fireballs above the parental impact craters, but also by Tunguska-like atmospheric phenomena produced by infalling projectiles that released their entire energy in the atmosphere and left no crater record.

We suggest that the investigated region was covered with a melt sheet. A rough estimate is that the mean thickness of the layer was ~4 mm, corresponding to a surface density of 10 kg m^{-2}. An equally rough estimate of the density of tektites that survived weathering and is still present in pristine regions is ~30 g m^{-2}. We suggest that an attrition factor of 300 is not inconsistent with that expected from weathering and other surface properties.

Large layered tektites are found from Hainan, China to Central Cambodia; we infer that melt sheets covered much of this 1200-km-long region. The ecological consequences of a melt sheet covering this region are enormous. All life within a few centimeters of the surface must have been destroyed.

D/H OF WATER RELEASED BY STEPPED HEATING OF SHERGOTTY, ZAGAMI, CHASSIGNY, ALH 84001, AND NAKHLA. L. L. Watson, S. Epstein, and E. M. Stolper, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125, USA.

We report the yield and D/H of water released by stepped heating of bulk Shergotty, Zagami, Chassigny, and the newest martian meteorite, ALH 84001 [1]. For comparison, we also report data from Nakhla using the same procedure since the heating steps in this study are slightly different than our previously reported nakhlite analyses [2]. With this work, we have completed a survey of D/H in bulk samples representative of all SNC mineralogical types. Assuming these meteorites are martian samples [3,4], the D/H of the water contained in SNC hydrous phases might be a useful tracer of water that once resided in the martian atmosphere (currently δD_{SMOW} ~ 4000 [5]) or has isotopically exchanged with it.

TABLE 1.

Sample	Weight (g)	δD (‰) 150°C	350°C	650°C	1000°C	Total Water (wt%)
Nakhla	0.58	−74	−82	−714	nd*	0.115
Chassigny	0.42	−40	−61	−12	−26	0.099
Shergotty	1.87	−69	−35	+666	+2061	0.042
Zagami	2.56	nd†	−1	+941	+1236	0.038†
ALH 84001	1.09	−51	+33	+532	+700	0.085

nd = not determined.
* Not enough H to measure isotope ratio.
† 150°C step lost.

A heating procedure similar to Karlsson et al.'s [6] was used to facilitate direct comparison to their O data in which high values of $\Delta^{17}O$ relative to bulk SNCs were observed in water released from some samples at high temperatures. Samples were heated under vacuum (pyrolysis) to temperatures of 150°, 350°, 600°, and 1000°C for 1–1.5 hr per temperature step. Our gas collection and analysis procedure has been previously described [2].

Hydrogen isotopic compositions of water released at each temperature step and total water yields for each sample are reported in Table 1. Yields generally agree with those of Karlsson et al. [6] except in the case of Shergotty, which was found to contain approximately one-third less water. Similar to earlier results for the nakhlites [2], isotopic compositions are terrestrial at low temperatures and δD values increase with increasing temperature for all samples except Chassigny. This pattern is consistent with mixing between low-temperature-adsorbed or -exchanged terrestrial water and indigenous water released at higher temperatures. Chassigny δD values are generally indistinguishable from terrestrial, becoming only slightly D-enriched (δD = 26) in the highest temperature step. This result is unexpected given that Chassigny reportedly has similarly anomalous $\Delta^{17}O$ values to the nakhlites [6]. The results are also surprising since we have previously measured high δD values (~800 to 1850) of amphiboles in Chassigny by ion microprobe [7,8]. Water released from these amphiboles may be responsible for the slight increase in δD at high temperature.

The δD of ALH 84001 water is similar to Nakhla, and is consistent with a martian origin for ALH 84001 [1]. ALH 84001 also contains macroscopic carbonates [1]. We have measured the $\delta^{13}C_{PDB}$ of the CO_2 released between 350° and 600°C to be 40.9. The yield was 0.13 wt%, representing 86% of the total CO_2 released in the entire experiment. This is the heaviest C ever reported in a martian meteorite sample.

The presence of D-enriched water in Shergotty is consistent with the results of Kerridge [9] who measured δD values up to 900 in Shergotty. However, the δD of 2061 reported here for the Shergotty 600°–1000°C temperature step is the highest ever measured in a whole-rock SNC. Both this study and our ion microprobe measurements [8] suggest that the shergottites may contain more D-enriched water than other SNCs. Although preliminary until further measurements can be made, this distinction may be reflecting the difference in geologic history or age [10] of Shergotty and Zagami relative to the possibly older and more deeply emplaced nakhlites, Chassigny and ALH 84001.

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AN ION MICROPROBE STUDY OF AN OSBORNITE-BEARING INCLUSION FROM ALH 85085. D. Weber[1,2], E. K. Zinner[2], and A. Bischoff[1], [1]Institut für Planetologie, Wilhelm-Klemm-Strasse 10, 48149 Münster, Germany, [2]McDonnell Center for the Space Sciences, Washington University, St. Louis MO 63130, USA.

Introduction: Minerals such as osbornite (TiN) or oldhamite (CaS) are the reduced high-temperature counterparts of the more oxidized refractory minerals (e.g., perovskite, hibonite, grossite) present in CAIs. Osbornite has been predicted to condense at high temperatures under highly reducing conditions (C/O ratio > 1; solar value 0.6) or to form as a product of gas-solid reactions under the still reducing conditions of C/O ≈ 0.8 [1,2]. In ALH 85085, a reduced carbonaceous chondrite, osbornite was found as a single grain (3 × 10 μm) in a small inclusion (15 μm in apparent diameter) [3,4]. Paragenetic minerals of osbornite within this inclusion are Ti-bearing spinel, a Ti,N,O phase, and a Ti,Al,Zr-rich phase [3,4].

Results: We determined Ti and N isotopic compositions and trace-element abundances of the osbornite by ion microprobe mass spectrometry. Because of the small size of the osbornite grain, we were not able to measure its compositions without contamination by surrounding phases. Isotopic compositions of N and Ti are indistinguishable from terrestrial and the Ti